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CORNING GLASS WORKS

ELECTRO-OPTICS LABORATORY

RALEIGH, NORTH CAROLINA

IMPROVED SCREEN FOR REAR PROJECTION VIEWERS

Technical Report No. - 11

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ABSTRACT

This report summarizes the first results of preliminary investigations on glass-ceramic and Fotoform^R samples. Two samples were found to give an axial gain of 2. and still meet the criteria for brightness uniformity. A program to determine the physical properties of these samples as to their particle size, relative refractive index, and number density is outlined. Some preliminary sine-wave resolution masks have been made. The status of this effort along with a completion schedule of the MTF analyzer is given.

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TECHNICAL REPORT NO. 11

1. Materials Investigation

A. Glass-Ceramics

A large number of glass-ceramic materials containing
different particle size and volume density have been
ground and polished. After preliminary testing, seven
of the most promising samples were measured in the
goniophotometer. The results are given in Figure 1
which shows the angular gain function versus the
scattering angle.

Some of the samples, mainly AC16C, AC18A, AC19A, and
AC19B, give very uniform screens but have correspond-
ingly low efficiencies because of multiple scattering,
Table I. The diffuse transmittance is the fraction
of light scattered into the forward hemisphere. The
I_{45}/I_o column is the fraction of incident light
scattered inside $\pm 45^\circ$. The thicker the sample, the
greater the probability of multiple scattering
occurring as can be seen by comparing the gain curves
of identical materials of different thickness, i. e.,
comparing AC16A with AC16C, AC18A with AC18B, and
AC19A with AC19B. The first two pairs show a change
in the shape of the scattering function with thickness,
which implies the order of scattering has changed.
This does not happen with the last pair indicating
that, even at the smaller thickness, the particle den-
sity is high enough so that high-order multiple
scattering still dominates. If this sample were cut
still thinner, the scattering curve would probably
show a maximum at $\theta = 0$, similar to AC18B. These
comparisons clearly indicate that optimization of
a material is important and can give a significant
improvement in its light-scattering characteristics.

Figure 1
Angular Gain Functions for 7 Samples
of Corning Glass Disks Materials
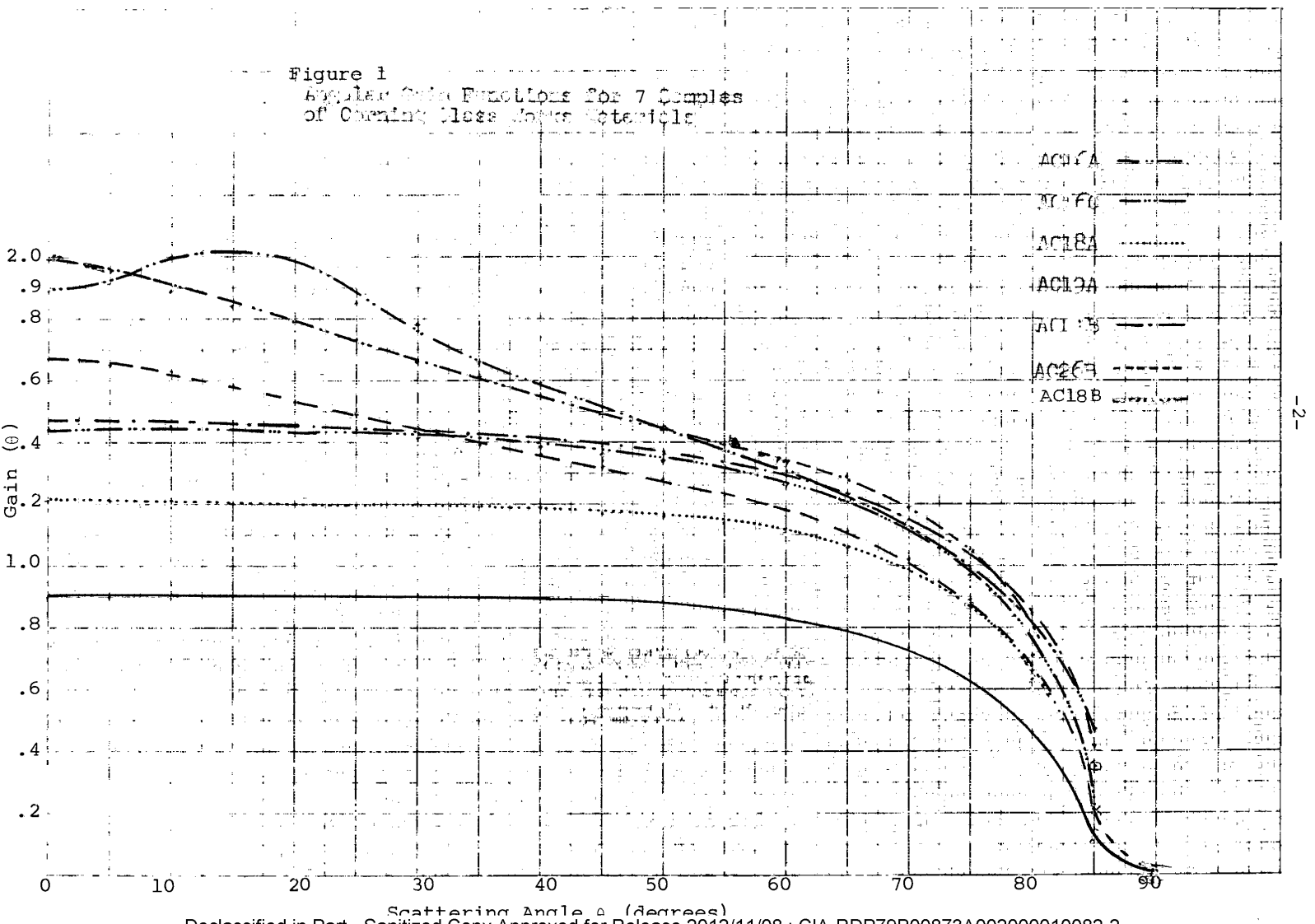
TABLE I

Summary of Optical Properties of the First CGW Samples

Sample	Diffuse Transmittance %	Diffuse Reflectance %	I_{45}/I_o %	Gain ($\theta=0$)	Thickness (mm)
AC16A	67	27	46	1.9	.366
AC16C	61	39	36	1.4	.864
AC18A	51	49	30	1.2	.861
AC18B	70	30	44	2.0	.345
AC19A	39	61	23	.9	.853
AC19B	62	38	34	1.5	.366
AC26B	61	39	38	1.7	.869

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Efficiency versus axial gain ($\theta = 0$) is plotted in
Figure 2 and compared with values predicted from
single scattering theory. The cluster of data around
the $M = \infty$ line indicates that multiple scattering
dominates, rather than implying the relative index
of refraction of the particles is infinite.

The best samples over all are AC16A and particularly
AC18B. Their variation in brightness is ±11%
and ±14% respectively, both less than the maximum
tolerance of ±15%. Here the variation in brightness
is computed from the relation

$$\text{Variation in Brightness} = \frac{\text{Gain } (0^{\circ}) - \text{Gain } (45^{\circ})}{\text{Gain } (0^{\circ}) + \text{Gain } (45^{\circ})} \, .$$

A detailed analysis of particle size, refractive index,
and number density of these samples is being made.
Electron micrographs will identify the particle geometry.
The other samples which have been ground and polished
will be measured, and the remainder of the better
original samples will be ground, polished, and tested.

B. Fotoform^{R} Glass

An investigation of Fotoform^{R} glass has been initiated.
Some promising materials have been obtained by not
exposing the samples to ultraviolet light and by
regulating the crystal growth with the time-temperature
development cycle. We have found this produces a layer
of crystalline material which is confined to the surface of
the glass. The thickness of this layer has been correlated
very well with temperature. Samples with crystalline
layers from 10 microns to 500 microns have been obtained
and are presently being prepared for optical evaluation.
Following this, practical-sized screen samples for visual
evaluation measuring 3" x 3" will be made using those
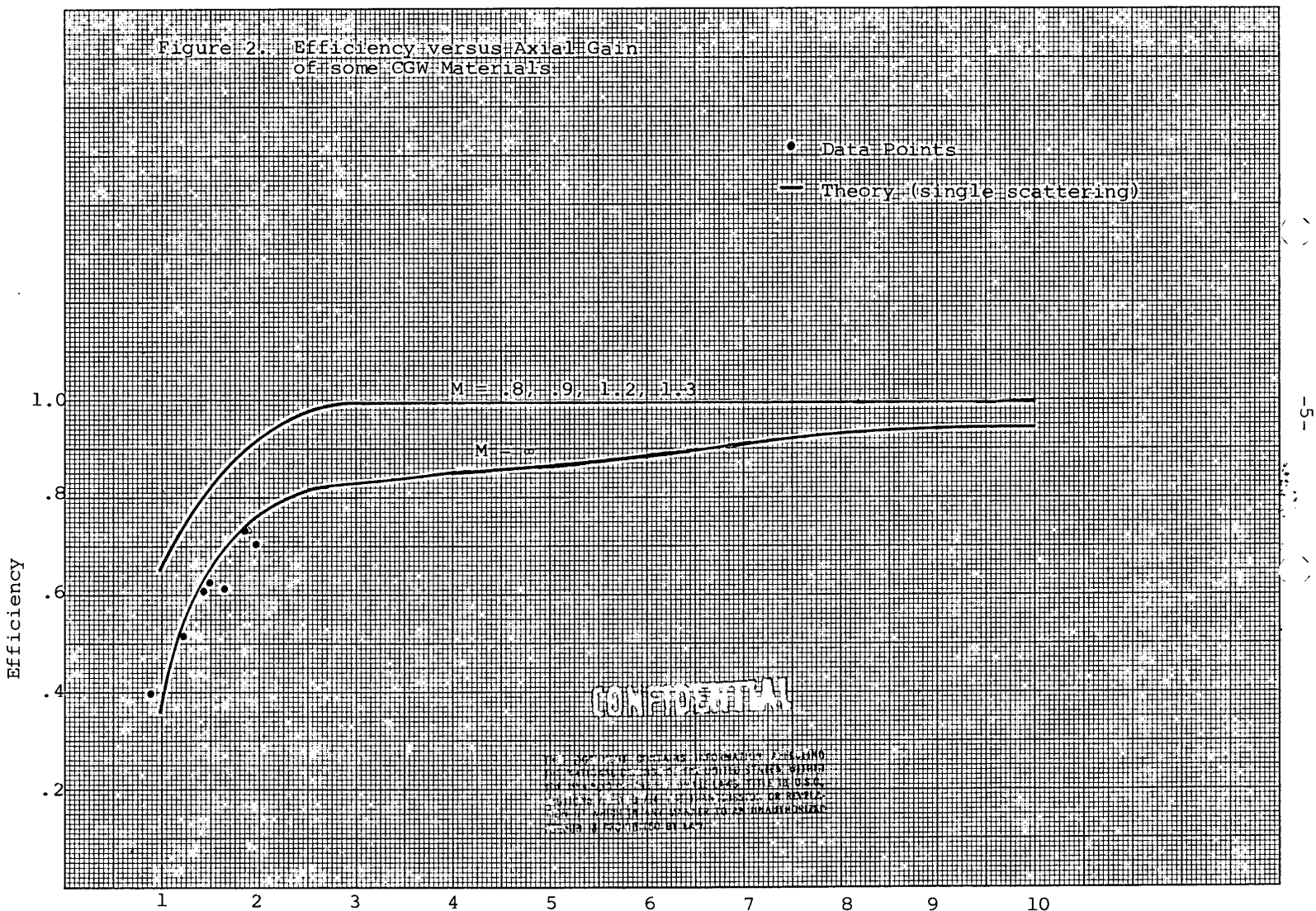heat treatments which result in optimum optical properties.

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Figure 2. Efficiency versus Axial Gain of some CGW Materials

Studies using different exposures together with different heat treatments are presently being carried out. We are also preparing to form lenticules on the surface of this material by exposing it through fine masks and by leaching away part of the glass.

C. Lenticular Surfaces

Samples of solid, spherical glass beads have been obtained which range in size from 65 microns to 325 microns. These, along with the cylindrical lenticular film, will be used for investigating lenticular surfaces.

2. Instrumentation

A. Goniophotometer

A refractometer was used to measure several solutions to determine their refractive index for use in the liquid sample cell of the goniophotometer. Several laboratory solvents were measured and all had refractive indices well below that of glass, which generally ranges between 1.47 and 1.52. Sugar in water, one of the better solutions, gave refractive indices between 1.33 and 1.48 at room temperature. Data were taken on the refractive index as a function of percent sugar, by weight. It was found that stock solutions can be made in this way with an accuracy of better than 0.2%, without requiring a refractometer. Solutions with n greater than 1.45 have very small crystals suspended in them which produce some undesirable scattering. Cinnamon oil had the highest refractive index measured, 1.605. This can be diluted with acetone down to n less than 1.4. The solution is somewhat yellow, but relatively nonvolatile. This mixture or a diluted refractive index oil will finally be used.

B.   MTF Analyzer and Sine-Wave Mask Generator

The unit has been set up to make sine-wave masks, and the system has been checked out. Several masks have been made, one of which is shown in Figure 3. These have spatial frequencies from 0.2 to 10 lines/mm, a ratio of 50:1. The spatial frequency has been shown to increase linearly with distance along the mask.
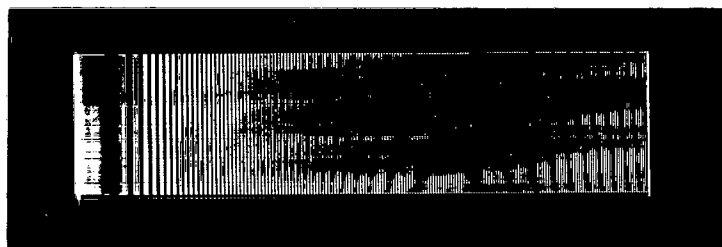

Figure 3.   A Typical Sine-Wave Resolution Target

There is sufficient light energy through the 10-micron slit, which is in contact with the film, to give the necessary densities. We have used a rotating polarizer in a collimated, polarized beam as the light modulator. This works quite well and no difficulties have been encountered with this unit. We are slightly modifying the film transport unit so that it will run smoother and

not produce differences in exposure along the film. The photodetector unit for use in the MTF configuration and for measuring the sine-wave masks has been completed and is working.

Dust in the slit, which is attracted to the film by static electricity, has been a problem. We have found that to prevent clogging of the slit and streaking of the film, the slit must be flushed with antistatic film cleaner and left to dry by evaporation each time before making a mask. We are also modifying the slit so that a stream of air will pass between it and the film. This we hope will keep the slit completely open by removing dust from the film before it passes in front of the slit. Final masks are expected within the next month.

Design of the "contrast computer" has been set; all necessary components are presently being ordered. Assembly is scheduled to begin by August 1 and completion is expected by September 1. Until then we will use an oscilloscope to collect MTF data on the more promising samples.